

TRP

July 18, 2001

Ms. Magalie Roman Salas
Secretary
Federal Communications Commission
The Portals, TW-A325
445 12th Street, SW
Washington, DC 20554

**Re: *Ex Parte* Notification – ET Docket No. 98-153
 Ultra-Wideband (UWB)**

Dear Ms. Salas:

There are documents attached to this letter to be filed as corrections to two Ex Parte documents filed in the above proceeding. The first document is a presentation presented on June 7, 2001 and the second is a document filed on June 19 at the request of the Commission. These documents are intended to replace the original documents.

Sincerely,

Phillip Inglis
Consultant for Time Domain Corporation

SEPARATION DISTANCE BASED ON MODIFIED HATA MODEL

The purpose of this paper is to compare the analysis provided by NTIA in their two reports, “Assessment of Compatibility Between Ultrawideband Devices and Selected Federal Systems”¹ (NTIA Report 01-43) and “Analysis of Electromagnetic Compatibility Between Radar Stations and 4 GHz Fixed-Satellite Earth stations”² (NTIA Report 94-313), with path loss equations used in an interference modeling approach developed in Europe known as SEAMCAT³. There is also a brief discussion, within the framework of actual usage of the transmitting device and the receiving device, of interference probabilities and the mitigation of interference when the relationships that must exist for interference to occur are not present. This analysis is compared to the NTIA Irregular Terrain Model (“ITM”) results for the scenario requiring the greatest separation distance to meet their protection criteria for communications systems analyzed in accordance with the techniques used in NTIA Report 01-43.

1. C/I Ratio Calculations

FSS Earth Station Path Loss Requirement:

NTIA Report 94-313 is an analysis of the susceptibility of fixed satellite earth stations (FSS) to interference from some Federal radar systems. The approach used in this analysis differs from that used in their analysis of the susceptibility of Federal systems to UWB emissions. Specifically, it used an acceptable C/I ratio to determine separation requirements, rather than using an increase in the noise floor in the IF stage to determine separation requirements.

¹ L.K. Brunson et al, [Assessment of Compatibility Between Ultrawideband Devices and Selected Federal Systems](#), NTIA Special Publication 01-43, January 2001.

² F. H. Sanders, R. L. Hinkle, and B. J. Ramsey, [Analysis of electromagnetic compatibility between radar stations and 4 GHz fixed-satellite Earth stations](#), July 1994. OSM Report, NTIA Report 94-313, July 1994.

³ Information on “[Spectrum Engineering Advanced Monte Carlo Analysis Tool](#)” (SEAMCAT) may be found at <http://www.ero.dk/EROWEB/SEAMCAT/Seamcat.html> and in ERC Report 68.

NTIA Report 94-313 used the following equation to calculate the required separation distance:

$$L_p = C/I - C + P_t + G_t + G_r - L_r - L_t - FDR, \quad (1)$$

The parameters are defined in Report 94-313⁴.

This same equation can be used to evaluate the susceptibility of FSS and SARSAT communications systems to UWB emissions. In the UWB case,

$$P_t + G_t - FDR - L_t \quad (2)$$

is a measure of FSS earth station or SARSAT station received interference power from an interfering UWB transmitter. For an FSS station it equals -11 dBm for the worst-case condition⁵ using a 1 MHz PRF with a UWB EIRP average value of -41.3 dBm/MHz. For higher PRF's, the separation distance requirements for both systems are typically lower.

The parameter values, as specified in NTIA Report 94-313, are:

$$C/I = 12 \text{ dB}$$

$$C = -100 \text{ dBm}$$

$$G_r = 32 \text{ dB}^6$$

$$L_r = 2 \text{ dB (nominal value)}$$

⁴ NTIA Report 94-313, p. 40.

⁵ A 1 MHz PRF was chosen as representing the worst-case scenario due to the peak level limiting factor proposed in the FCC NPRM. That is, the power emitted by UWB devices operating with lower PRF's is capped by the peak limit.

⁶ 32 dB was used here because gain patterns for higher gain antennas were not available. Earth station antennas licensed for reception of radio transmissions from a space station in the fixed satellite service are afforded less protection from interference from coordinated terrestrial radio transmitters if their 1 degree off axis gain exceeds 32 dBi. Based on Figure 16 in NTIA Report 94-313, earth station antennas with main lobe gains exceeding approximately 36 dBi would be expected to have 1 degree off axis gains exceeding 32 dBi.

$$L_t = 2 \text{ dB (nominal value)}$$

$$\text{FSS IF BW} = 30 \text{ MHz}$$

Substituting into (2) and incorporating a 12 dB C/I ratio yields:

$$L_p = 12 - (-100) + 32 - 2 - 11 = 131 \text{ dB} \quad (2)$$

Using the free space attenuation formula to calculate separation distance at a frequency of 3700MHz gives the following result.

$$L_p = 131 \text{ dB} = 32.4 + 20\log(f) + 20 \log(d) = 32.4 + 71.36 + 20 \log(d)$$

$$d = 23 \text{ km}$$

which represents the separation distance for antennas in basic alignment with each other. To compare this distance to the distance computed by the ITM model using a UWB antenna height of 30 meters and a receive antenna height of 3 meters, we must correct for the 5 degree off-axis antenna alignment used by NTIA. A 5 degree off-axis alignment reduces the earth station antenna gain approximately 16 dB relative to an antenna maximum gain of 32 dBi. Based on compliance with the antenna gain pattern requirements of Section 25.209 of the FCC rules, for antennas with gains above 32 dBi, the reduction in gain would equal 16 dB +(Antenna gain above 32dBi(dB)).

Recalculating with 5° off-axis alignment yields:

$$L_p = (131-16) \text{ dB} = 32.4 + 20\log(f) + 20 \log(d) = 32.4 + 71.36 + 20 \log(d)$$

$$d = 3.65 \text{ km}$$

For the same scenario, the NTIA ITM model calculated a distance of 10.1 km for a PRF of 1 MHz.

At these distances additional factors, identified below, must be included in order to realistically represent the distance separation required.

Real World Factors. At a minimum, factors that should be included in modeling analysis using path loss calculations for calculating separation distances in addition to earth station antenna angular elevation and antenna heights are terrain variations, atmospheric conditions, foliage, buildings and other man-made structures.

SARSAT LUT Path Loss Requirement

Using the above analysis and substituting the appropriate parameters in the equation provides the following results.

Again using $C/I = 12$ dB as a nominal value for communications systems

$C = -116$ dBm based on a received signal level 1 dB above the system noise floor specified in Report 01-43

$G_r = 27$ as specified in Report 01-43

$L_r = 2$ dB from 94-313 (nominal value)

Power in SARSAT receiver BW – 42 dBm

$$L_p = 12 - (-116) - 42 + 27 - 2 = 111$$

$$20\log(d) = 111 - 32.4 - 64 = 15$$

$$d = 5.4 \text{ km}$$

For this scenario, the NTIA ITM model calculated a distance of 11.3 km for a PRF of 1 MHz.

At these distances the additional factors previously identified must be included in calculating a realistic separation distance based on path loss requirements.

2. Comparison of Separation Distances Based on Propagation Modeling Programs.

A search of available analysis programs implementing path loss models that incorporated most if not all of the additional factors previously identified concluded the European

SEAMCAT analysis program came closest. This program uses a modified Hata propagation model to extend the applicability of the model to frequencies up to 3 GHz and for distances up to 100 km for urban, suburban and open area purposes. From the documentation available, it appears to include most of the factors specified above with the exception of foliage attenuation and atmospheric conditions in the range of frequencies up to 3 GHz. For frequencies above 3 GHz, the SEAMCAT program uses a spherical diffraction model that is not recommended to be applied to our scenario of a victim receiver and interfering source at short distances in relatively close proximity to the ground.

Of the additional factors affecting separation distance based on path loss requirements previously mentioned, it appears that the NTIA model accounted only for earth curvature, antenna gain alignment, and antenna height considerations. Although part of the ITM program capability, NTIA did not include any adjustment for terrain variations or system losses.

For the SARSAT analysis a SEAMCAT path loss formula that is based on a modified Hata model for outdoor to outdoor urban environment in the frequency range of 1500 – 2000 MHz was used as follows.

$$L = 46.3 + 33.9(f) - 13.82 \log(\max\{30; H_b\}) + \alpha \cdot [44.9 - 6.55 \log(\max\{30; H_b\})] \log(d) - a(H_m) - b(H_b)$$

where:

$$a(H_m) = (1.1 \log(f) - 0.7) \cdot \min\{10; H_m\} - (1.56 \log(f) - 0.8) + \max\{0; 20 \log(H_m/10)\}$$

$$b(H_b) = \min\{0; 20 \log(H_b/30)\}$$

$$H_m = \min(h_1, h_2)$$

$$H_b = \max(h_1, h_2)$$

$$\alpha = 1 \text{ for distances } \leq 20 \text{ km}$$

h_1 and h_2 refer to Tx and Rx antenna heights

Using the C/I determined path loss for direct antenna alignment and inputting parameters for a 2 meter UWB antenna height and a 12 meter SARSAT antenna height, a separation distance requirement of $d = 0.145$ km is computed, which is below the 0.200 km distance criterion specified in NTIA Special Publication 01-43. Taking into account antenna gain reduction due to off axis alignment of the respective antennas reduces the above distance to approximately 0.112 km. This distance compares to 4.2 km listed in the NTIA report. For devices operated indoors the separation distance would be further reduced by a factor for wall attenuation. Wall attenuation factors tend to vary from 10 to 15 dB with the FCC using 12 dB in previous rulemakings. A factor of 12 dB reduces the distance separation below the range of applicability of the above formula but it is estimated that the distance is of the order of 50 to 75 meters or less.

Recalculating the above but using a UWB antenna height of 30 meters, the separation distance is 1.17 km. Antenna angular alignment variations are of little significance at these distances with these antenna heights. However, in this scenario at this distance, the UWB antenna is higher than the SARSAT antenna when it is pointed at the horizon and any building structure containing the UWB device would be in the path of the intended received satellite signal thus blocking the satellite signal. The point is that the SARSAT LUT would have no expectation of receiving a satellite signal in the direction of a UWB device that was housed within a building structure because of the building. In any event, UWB devices associated with the building would be operated within the building where wall attenuation is a contributing factor. Including wall attenuation in the path loss and recalculating, the separation distance $d = 0.537$ km. It should be noted that the above does not include path loss corrections related to foliage and atmospheric absorption or diffraction effects due to other man-made structures potentially affecting the beam of the SARSAT antenna when pointed at the horizon. For comparison purposes the NTIA report specifies a separation distance of 11.3 km for the above scenario of a 12 meter SARSAT antenna height and a 30 meter UWB antenna height.

Regarding probabilities of interference, based on the results presented above, one must recognize the interference probabilities are extremely low and considering the normal operation and location of a SARSAT LUT terminal the probability of interference is further minimized. Optimal SARSAT receiving sites are either open flat plains or elevated above any surrounding structures either natural or man-made. A 30 meter tall building at a range of 500 meters would probably constitute a significant obstruction to SARSAT performance if its antenna height were 12 meters. For example, based on a smooth earth model, a 12 meter high SARSAT antenna would see a horizon approximately 14.2 km away. However, any physical structure at this distance would be above the horizon, thus blocking satellite signal reception in that direction. Obviously, any physical structure higher than 12 meters at any distance from the SARSAT antenna would block satellite signal reception if it fell in the path between a SARSAT antenna pointed on the horizon at a satellite in that direction based on a smooth earth model.

There are additional operational considerations in analyzing probabilities of interference. SARSAT LUT systems are intended to track a low earth orbit satellite in a polar orbit. The antennas usually start at or near the horizon for the environment in which they are located and track a satellite as it rises and then falls to the next horizon. Estimates of rate of change of angular orientation as the satellite moves across the sky are approximately 12 degrees/minute. At this rate of change, any signal from a UWB source or other device that happened to be in the main beam would be out of the main beam quickly and within a minute or so its level would be approximately 22 dB lower than the level referenced to alignment on the main beam. Within approximately 2 minutes, the UWB source level would be 30 dB or more down when referenced to alignment on the main beam. Even in the highly unlikely event that interference was perceived by the SARSAT LUT at any point from any source with a power level comparable to a UWB transmitter power level as its antenna tracked a satellite the interference would be eliminated as a function of normal operation within a very short period of time. Further, it appears that satellite acquired data from a 406 MHz EPIRB is stored in the SARSAT satellite and continuously retransmitted until replaced by new data allowing numerous opportunities for transmission and reception of this data. Real time signals operating at 121.5 and 243 MHz are continuously retransmitted as long as the path from the EPIRB to the satellite is

available allowing ample opportunity for successful reception by a LUT. There are also several redundant LUT terminals worldwide, approximately 34, with 7 in operation in the United States in addition to multiple satellites. In short, the SARSAT LUT system is a very robust system.

For FSS earth stations, the SEAMCAT modified Hata path loss model is not specified for use above 3 GHz. However, comparative conclusions can be drawn by recalculating the NTIA separation distance requirements for a frequency of 3GHz using the NTIA ITM program and comparing these results to the results using the SEAMCAT path loss model. Recalculating the NTIA model for 3000 MHz, we have separation distances quite similar to the distances calculated at 3750 MHz. This is to be expected since the ITM documentation indicates it is largely insensitive to frequency changes. The revised distance at 3000 MHz based on the NTIA ITM model for a 2 meter UWB height is 2.98 km and for a 30 meter UWB antenna height is 12.05 km.

Using the following formula from the SEAMCAT analysis for frequencies in the range of 2000 to 3000 MHz we can calculate the separation distance based on path loss requirement determined using the C/I ratio and parameters from NTIA report 94-313 for UWB antenna heights of 2 meters and 30 meters.

$$L = 46.3 + 33.9\log(2000) + 10 \log(f/2000) - 13.82\log(\max\{30;H_b\}) + \alpha \cdot [44.9 - 6.55\log(\max\{30;H_b\})]\log(d) - a(H_m) - b(H_b)$$

$A(H_m)$, $b(H_b)$, and α were defined previously, $H_m = 2$, and $H_b = 3$ for an FSS antenna height of 3 meters, 5 degree elevation angle and a UWB antenna height of 2 meters.

Calculating the distance separation required using the above formula gives a separation distance of 0.172 km. In order to compare it to the NTIA value we must also include a correction for antenna alignment. It is estimated that the off axis antenna alignment will result in a reduction of antenna gain of more than 12 dB. Incorporating a 12 dB adjustment to make a comparison with the NTIA ITM model, we get a separation distance of 0.078 km. It is recognized that this distance is below the range of applicability of the SEAMCAT formula for minimum distance which is 100 meters, but

for comparative purposes, it shows the significant differences between a more realistic propagation model using a C/I ratio for path loss requirements versus the NTIA ITM model which appears to be based on the Longley-Rice propagation model adjusted for smooth earth parameters .

Using the above equation and calculating the required separation distance for a UWB antenna height of 30 meters, we get a distance of 0.777 km. Again, in order to make a comparison we must adjust for antenna alignment. It is estimated that the antenna off axis alignment factor is 7 dB based on the gain pattern formula in Section 25.209 of the FCC Rules relative to a maximum gain of 32 dBi. Applying this correction to the equation, we calculate a separation distance of 0.492 km. Applying a 12 dB wall attenuation factor the distance calculates to 0.225 km. It must be recognized that the separation distance of 0.225 km is based on a model than incorporates path loss adjustment for terrain height variations among other things. For a smooth earth model, at this distance the UWB antenna would be in the main beam of the FSS earth station antenna out to a distance of approximately 300 meters. It is also apparent that the structure supporting or housing the UWB device would block the satellite signal if the earth station antenna is pointed in the direction of the UWB device .

Here again we should note that no attenuation for atmospheric conditions nor for foliage has been included in the above calculations although at these frequencies, the additional attenuation would be significant particularly in view of the FSS antenna siting only 3 meters off the ground. UWB sources will typically be in or near buildings and other man-made structures that would preclude low elevation angles for the FSS earth stations. To receive a satellite signal, the FSS antenna main beam direction would have to avoid such objects in the path. *The need for an FSS earth station antenna to avoid alignment or near-alignment with natural or man-made structures provides a significant reduction in the probability of interference to the FSS station from any intentional or unintentional RF source particularly those having a power level that is comparative with the power level permitted a UWB device.* In effect, there is no expectation of receiving a satellite signal if the path is obstructed by physical structures that would be needed to support UWB operation.

Foliage attenuation has been previously mentioned and is a factor that is considered to be important in practical applications. For example, the Johns Hopkins Applied Physics Laboratory in cooperation with the University of Texas has published a handbook regarding propagation effects in vehicular and personal mobile satellite systems⁷. Section 2 of that handbook is devoted to attenuation due to trees and concludes that the average single tree attenuation at L band (1.6 GHz) is 11 dB⁸. Using the formula provided, the average single tree attenuation at C band (4.0 GHz) would be approximately 14 dB. As indicated in the handbook, many of the findings in the handbook are supported by similar work reported in ITU-R PN.681-1.

3. Conclusion

The application of more realistic traditional interference models shows that NTIA's analysis greatly over estimates the required separation distance between UWB devices operating at FCC Part 15 Class B power levels and SARSAT and FSS stations. These traditional models base separation distance requirements on path loss requirements that reflect real world variables for terrain, obstructions and clutter. Neither of the modeling approaches actually pertains to the probabilities of interference that exist when the systems are in operation. The NTIA analysis used a performance criteria based on a bore sight technique to generate an increase in receiver IF output of 1dB or less which does not seem appropriate for communications systems. The SEAMCAT and NTIA ITM models did not include factors for operational conditions such as duty cycles or antenna rotation, foliage, etc. For the SARSAT system, antenna alignment is a function of satellite tracking requirements. For FSS earth stations, antenna alignment to receive a satellite signal must take into account natural and man-made obstacles in the line-of-sight path. When taken into consideration, these operational factors serve to further minimize the already low probability of any interference.

⁷ Julius Goldhirsh and Wolfhard J. Vogel, *Handbook of Propagation Effects for Vehicular and Personal Mobile Satellite Systems*, December 1998.

⁸ Id, p. 2-15.

Based on the above it is apparent that UWB devices operating at a power level equivalent to that which produces 500 uV/m measured at three meters, will easily meet the Part 15 requirement of not generating harmful interference to licensed radio services including the SARSAT and Fixed Earth Station services. The following table compares the results of a traditional approach to modeling distance separation based on path loss and the approach NTIA chose to use in the UWB proceeding. In the UWB proceeding, NTIA considered that UWB devices with a calculated separation distance from a victim receiver of 200 meters or less met their protection criteria. Using the more traditional approach UWB devices with an antenna height of 2 meters show separation distances much less than 200 meters without including factors related to atmosphere, foliage or wall attenuation thus clearly meeting the requirement. For a UWB height of 30 meters, the separation distance from the FSS earth station is 225 meters when including a factor for wall attenuation leaving only the SARSAT LUT terminal as basically not meeting the stated NTIA protection criteria. In this scenario the UWB antenna is much higher than the SARSAT antenna, which is not a likely real world scenario since the SARSAT satellite signal would be blocked by the structure supporting the UWB device.

SEPARATION DISTANCE COMPARISON TABLE

PRF - 1 MHz* **Distance in km**
to Meet NTIA's Criterion

UWB Antenna Height	SARSAT			Fixed Earth Station (3000 MHz)		
	SEAMCAT		NTIA	SEAMCAT		NTIA
	Wall	No wall		Wall	No wall	
2 meters	0.050- 0.075**	0.112	4.2	0.040- 0.060**	0.078	2.98
30 meters ***	0.537	1.17	11.3	0.225	0.492	12.05

*At higher PRFs, the distances would be expected to be shorter.

**Denotes that the level is estimated based on propagation formula.

***At this UWB antenna height, the height of the building would likely block satellite antenna reception if the building were in line with the satellite and the satellite receive antenna.

TIME DOMAIN

THE PULSE OF THE FUTURE

UWB: The 50 MHz Limit & Noise-likeness

TIME DOMAIN

Discussion Outline

- ▶ The 50 MHz Limit as presently proposed
 - ▶ What problems are created for the UWB industry by the 20 dB limit
 - ▶ Objective of the limit
 - ▶ Restrictive 20 dB limit in NPRM
 - ▶ Impact on UWB Technology
 - ▶ An appropriate peak limit
 - ▶ A 41 dB limit is a good balance
- ▶ Defining sufficient noise-likeness

Objective of the Peak-to-Average Limit

- ▶ The 20 dB peak limit as measured in a 50 MHz bandwidth was proposed as a means of controlling peak level interference
- ▶ Limits peak pulse amplitude thereby controlling peak-related interference potential
 - ▶ Prevents front-end overload in a victim receiver

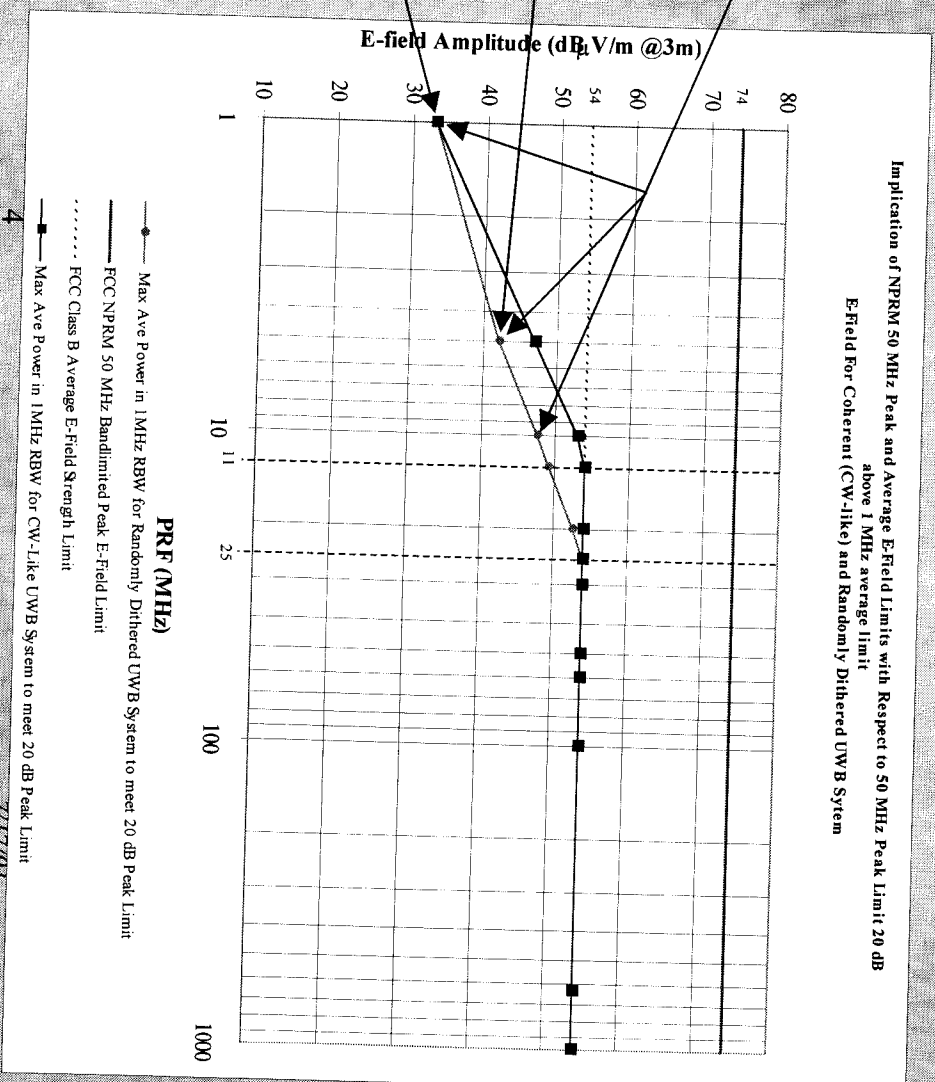
The 50 MHz Limit

- As proposed in the NPRM, the lower the PRF, the lower the reduction in average power has to be

TM-UWB Emitter PRFs Used for Texas GPS Testing

TDC Through-Wall Radar PRF & PRF of Emitter Used by TDC for its GPS Test

Typical GPR PRF & Used in Texas Testing



Impact of the 20 dB limit on UWB Technology

- ▶ Using NTIA's Pulse Response Formulas, average power reductions can be calculated.
 - ▶ For dithered UWB technology, PRFs below 23-25 MHz are affected. For example, a 1 MHz PRF system would require a 21 dB reduction in average power.
 - ▶ For non-dithered technologies, PRFs below 11 MHz are affected. For example, a 1 MHz PRF system would require a 21 dB reduction in average power.

20 dB Value on 50 MHz Peak Limit is Problematic

- ▶ Restricts use of lower PRF systems
- ▶ Radar Applications – most are precluded
 - ▶ TDC's radar vision - (e.g., through-wall sensing)
 - ▶ Requires lower PRF for maximum range
 - ▶ Severe average power reduction is required
 - ▶ GPR in general has similar problems
- ▶ Applications also constrained
 - ▶ TDC's tracking system
 - ▶ Inventory monitoring
 - ▶ Medical communication & tracking applications

Problems (cont'd)

- ▶ Restricting UWB applications to high PRFs may increase potential impact on GPS
- ▶ GPS studies conclude that pulse-like signals (where PRF is smaller than RBW) are less of a problem for GPS than white noise or noise-like UWB signals.
- ▶ Lower PRFs are more pulse-like than higher PRFs

Derivation of an Appropriate Peak Limit

- ▶ NTIA did not account for the proposed 20 dB peak to average limit and its effect on average power in its non-GPS report.
- ▶ NTIA did not reduce the average powers of the UWB systems tested, and as a result, the 1 MHz PRF systems actually had peak power levels that were 41 dB above the average limit.
- ▶ For 1 MHz PRF systems, dithered and non-dithered UWB signals evoke the same response level in a 50 MHz measurement bandwidth.

TIME DOMAIN

Comments on NTIA's Average Power Analysis

- ▶ NTIA analyzed 15 non-GPS systems in the 1-6 GHz range for average UWB power susceptibility.
- ▶ PRFs below 1 MHz generally showed a 10 dB higher interference potential
 - ▶ A 10 dB/decade reduction in average power for UWB PRFs below 1 MHz will equalize average power interference potential for PRFs over the 0.001 MHz to 500 MHz range.
 - ▶ A 41 dB peak limit forces this 10 dB/decade reduction in average power below 1 MHz PRFs, negating the 10 dB higher interference potential noted by NTIA.

TIME DOMAIN

NTIA Criteria Not Exceeded Using a 41 dB Limit

- ▶ Implementing an average power reduction for low PRF systems based on a 41 dB peak to average ratio, and incorporating an additional path loss figure, shows that UWB devices operating at -41.3 dBm EIRP power levels will not exceed the protection criteria NTIA used in its analysis.

Comments on NTIA's Peak Power Analysis for 30m and 2m UWB antenna heights

- ▶ Of the 15 non-GPS systems examined by NTIA, 2 communications systems were further analyzed based on UWB peak power susceptibility.
- ▶ NTIA used a 1 dB increase in the system noise floor as its criterion for harmful interference in lieu of the the industry standard C/I ratio criterion.
 - ▶ For a SARSAT Station, NTIA calculated a minimum separation distance of 11.3 km (30m height) and 4.2km (2m height) for a 1 MHz PRF UWB power level of 41.3 dBm
 - ▶ For a FSS Earth Station (5° elevation), NTIA calculated a minimum separation distance of 10.1 km (30m height) and 3.0km (2m height) for a 1 MHz PRF UWB power level of 41.3 dBm

Peak Power Analysis for SARSAT and FSS Using the Industry C/I Ratio

- ▶ First, calculate the path loss:
 - ▶ $L_p = C/I - C + P_t + G_t + G_r - L_s - L_r - FDR$
 - ▶ Source: NTIA Report 94-313 “Analysis of electromagnetic compatibility between radar stations and 4 GHz fixed-satellite Earth stations”, July 1994
- ▶ Then, solve for D, the minimum separation distance, using the Hata model for urban environments
 - ▶ $L = 46.3 + 33.9(f) - 13.82 \log(\max\{30; H_b\}) + \alpha \cdot [44.9 - 6.55 \log(\max\{30; H_b\})] \log(d) - a(H_m) - b(H_b)$ or
 - ▶ $L = 46.3 + 33.9 \log(2000) + 10 \log(f/2000) - 13.82 \log(\max\{30; H_b\}) + \alpha \cdot [44.9 - 6.55 \log(\max\{30; H_b\})] \log(d) - a(H_m) - b(H_b)$
- ▶ When parameters for SARSAT and FSS systems given in NTIA reports and FCC proposed limits for UWB power levels for a 1 MHz system are used, the separation distance is significantly reduced!

Peak-Related Interference Results Comparison for UWB Antenna Heights of 30m and 2m

NTIA non-GPS Criterion

Industry Standard Approach

SARSAT – 11.3km (30m);

SARSAT w/wall – 0.537km

4.2km (2m)

(30m); 0.050-0.075km (2m)

FSS – 10.1km (30m); 3.0km
(2m)

FSS w/wall – 0.225km (30m);
0.040-0.060km (2m)

- ▶ NTIA'S analysis used incorrect performance criterion (raising noise floor by 1 dB vs. industry standard C/I ratio) and did not recognize additional path loss factors.

- ▶ NTIA Report 94-313 related to radar interference used the industry standard C/I ratio with a smooth earth model and stated for detailed EMC analysis, additional path loss factors should be included.

TIME DOMAIN

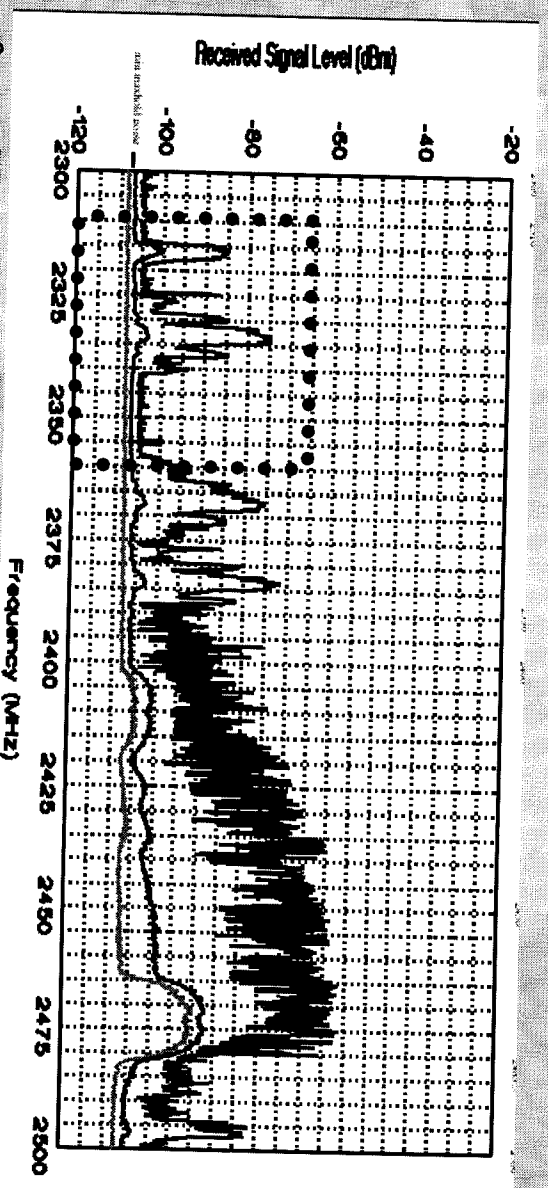
Other Factors That Further Reduce the Impact of UWB

- ▶ Worst-case calculation by NTIA that led to the 10.2 and 11.3 km distances assumed an undithered UWB signal.
- ▶ Worst-case calculation by NTIA that led to the 10.2 and 11.3 km distances assumed UWB height of 30m – this only makes sense if the UWB device were indoors, which adds further attenuation.
- ▶ Building blockage of satellite signals would occur for direct alignment of an RF Source (UWB or otherwise) between the satellite and the SARSAT or FSS antenna
- ▶ At low elevation angles, FSS systems would also detect radar signals that would likely be at higher powers than UWB is proposed to be.

TIME DOMAIN

Consumer Satellite Services in the 2 TO 2.5 GHz Band

- ▶ NTIA Technical Memorandum 92-154 shows emissions in the 2310 to 2360 MHz band
 - ▶ Radars
 - ▶ Microwave ovens
 - ▶ ISM-band industrial equipment
- ▶ "Above 2350 MHz, the probability is high that the BSS receiver will detect microwave oven pulses consistently above its threshold in any of its intended operating environments."
- ▶ "Below 2350 MHz, pulse amplitudes are lower, but still above the threshold at short distance in a home or between apartments."



Source: NTIA Broadband Survey of San Diego, CA

TIME DOMAIN

Emissions from Microwave Ovens

- ▶ Another NTIA report emphasizes the noise level in the 2310 to 2360 MHz band

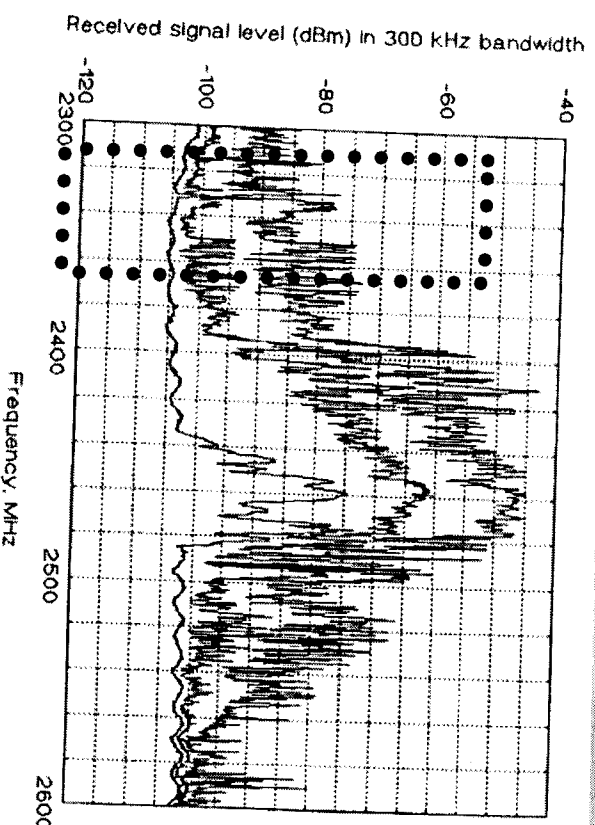


Figure 3-11. Aggregate emission spectrum outside apartment complex
4:30 - 7:30 PM weekday

Source: NTIA Technical Memorandum 92-154

THE DOMAIN

Noise-likeness

- ▶ Time Domain believes that a test for UWB noise-likeness makes sense.
- ▶ A properly designed UWB signal is like, but not identical to, white noise.
- ▶ Using too narrow an RBW favors high PRF systems

Conclusion

- ▶ A 41 dB peak to average limit poses no interference threat, and allows for the deployment of a wide range of UWB applications.
- ▶ Peak power effects reported by NTIA for SARSAT and FSS are incorrect and overstated.
- ▶ A test for noise-likeness should be applied carefully.